

Basic Study on the Environment of Cambodia

(A Summary Translated from the Japanese Report)

July 1996

Japan Sotoshu Relief Committee (JSRC)
Research Group for Cambodian Environment

Contents

Preface

1. Purposes of the Study, and Activities Carried Out
2. Outline of Cambodia
3. Environmental Situation of Present Cambodia:
 - Results of Interview and Field investigation -
4. Basic Study of Environmental Pollution (1):
 - Preparatory Study on Mercury Pollution -
5. Basic Study of Environmental Pollution (2):
 - Preparatory Study of Agricultural Chemicals' Pollution -
6. Summary of the Study and Perspectives of Further Investigation

Postscript

A List of Published Papers

*Notice: Before reading this paper, we would like you to forgive some inappropriate words which we use here.

1. Purposes of the Research, and Activities Carried Out

1-1. Purposes of the study and this report

In 1995, Japan Sotoshu Relief Committee (JSRC) decided to start a program which intended to improve issues about environment in Cambodia. In order to give a long-term perspective for the program, a research group were dispatched to Cambodia by JSRC, first in November 1995 and next in February 1996. This report is the results of the research.

1-2. Outline of the Research Activities in October 1995

Figure 1.1 shows members of the first group dispatched in October 1995. Figure 1.2 shows the outline of research activities carried out by the group.

Fig. 1.1 Members of the Delegation in November 1995

name	affiliation (specialty)
Dr. Yukio Takahashi	Professor, Niigata University, Faculty of Engineering (Water quality management)
Dr. Toshikazu Saeki	Postdoctoral Fellow, Ehime University, Faculty of Agriculture (Measurement of environmental micropollutants)
Mr. Yuji kashima	Research Assistant, Yokohama City University, School of Medicine, Department of Hygiene (Measurement of environmental micropollutants)
Ms. Naoko Watanabe	Researcher, Ostrand Inc. (Solid waste management)

Table 1.2 Outline of Research Activities (November 1995)

●11/21/95 (Tuesday)	
visit	Ministry of Environment. Courtesy call.
reception	Mr. Heng Nareth, Construction Engineer, Under State Secretary, Deputy Director of Dept. of Control, prevention and Reduction of Pollution Mr. Chim Rottha, Economic Planning Engineer, Deputy Director of Dept. of Control , prevention and Reduction of Pollution
visit	Japan International Volunteer Center (JVC)
reception	Mr. Toshihiro Shimizu, Representative Ms. Hirono Azuma, Environmental Scientist
●11/22/1995 (Wednesday)	
visit	Ministry of Agriculture, Forestry and Fisheries, Dept. of Agricultural Hydraulic and Hydro-Meteorology,
reception	Mr. Veng Sakhon, Deputy Director Mr. Chea Sophala, Chief of Laboratory
visit	Ministry of Agriculture, Forestry and Fisheries, Dept. of Fisheries
reception	Mr. Long-Chheang, Chief of Planning/Accounting Office
visit	Waterworks of Phnom Penh City
reception	Mr. Hiroo Horiuchi, Project Manager, Kubota Construction Co., Ltd, Phnom Penh Office
●11/23/95 (Thursday)	
visit	Ministry of Rural Development, Dept. of Rural Health Care
reception	Dr. Chea Samnang, Director 他 2 名
visit	A farm village in Kampong Spoe
●11/24/95 (Friday)	
visit	A solid waste dump site in Strung Mean Chey
reception	Phnom Penh Municipality, Dept. of Public Work and Transportation
visit	Phnom Penh Municipality, Dept. of Public Work and Transportation
reception	Mr. Keo Savin, Director
●11/25/1995 (Saturday)	
visit	Ministry of Agriculture

reception	Mr.Touch Seang Tana and Mr. Nicolaas P. Van Zalinge
visit	Red Cross of Cambodia
reception	Study meeting of Japanese experts and volunteers on health
●11/26/1995 (Sunday)	
	Fish and sludge sampling on the Sap River by boat from Phnom Penh Port to a point 20 km upstream of the port, accompanied by an official of Dept. of Fisheries
●11/28/1995(Tuesday)	
	Survey of Phnom Penh City (1), accompanied by two officials of the Ministry of Environment
●11/29/1995 (Wednesday)	
	Survey of Phnom Penh City (2), accompanied by two officials of the Ministry of Environment
●11/30/1995 (Thursday)	
visit	Ministry of Environment. Courtesy call.
reception	Dr. Seng-Oeurm, Secretary of State, Secretariat for Environment

1-3. Outline of the Research Activities in February 1996

Figure 1.3 shows the members of a research group dispatched in February 1996. Figure 1.4 shows the outline of research activities of them.

Table 1.3 Members of the Delegation (February 1996)

name	affiliation (specialty)
Mr. Yuji kashima	Research assistant, Yokohama City University, School of Medicine, Department of Hygiene (Measurement of environmental micropollutants)
Dr. 松井三明	International Medical Center of Japan, Department of Obstetrics & Gynecology (Present post: Research assistant, Yokohama City University, School of Medicine, Department of Hygiene) (Medical doctor)

Table 1.4 Outline of Research Activities (February 1996)

●2/5/96 (Monday)	
visit	Ministry of Environment and Ministry of "Agriculture, Forestry and Fisheries"
activities	Courtesy call. Mercury and pesticides concentration in fish caught in the previous visit was shown.
visit	Printing factory of Japan Sotoshu Relief Committee (JSRC)
activities	Detailed interview on fish consumption with 31 workers whose head-hair was sampled in the previous visit and 18 workers whose hair was not sampled in the previous visit.
●2/6/96 (Tuesday)	
visit	24 Hours' TV Hospital
activities	Visit to 24 Hours' TV Hospital in a rural farming area to know effects of pesticides on human body. 13 samples of mother's milk and 25 samples of head-hair (12 couples of mothers and their children) were gained. In addition, present situation and issues in this hospital from a view point of regional medical care was investigated.
Visit	Center for mother and baby's health in Phnom Penh
●2/7-8/96 (Wednesday & Thursday)	
visit	Purchase and sampling of fish and head-hair
activities	Purchases of substantial number of fish in main markets in Phnom Penh City to know amounts of pesticides and heavy metals in them. Visit to fishing villages along the Sap, the Bassac and the Mekong River to sample head-hair and to interview on food consumption, accompanied by two officials of the Ministry of Environment and the Ministry of Fisheries.
●2/8/96 (Thursday)	
visit	a slaughterhouse
activities	Investigation of a shipping source of meat distributed in Phnom Penh City

2. Outline of Cambodia

In this chapter, the outlines Cambodia are described from various point of view. Its contents are as follows.

2-1. Geographical Location

2-2. Territory

2-2-1. Geographical features

2-2-2. Land Utilization

2-3. Climate

2-4. Outline of the History

2-4-1. Features of the Cambodian history

2-4-2. Till French colonial era

2-4-3. From its independence to present day

2-5. Government

2-5-1. Birth of the kingdom of Cambodia

2-5-2. Present governmental structure

2-6. Economy

2-6-1. Outline

2-6-2. Industry

2-7. Population

2-8. Public Health and Education

2-8-1. Public health

2-8-2. Education

2-9. Relationship with Japan

2-9-1. Aid of Japanese government to new Cambodia

2-9-2. Economic and technical aid of Japan

2-9-3. Economy and trade

2-10. Miscellany

3. Environmental Situation of Present Cambodia

- Results of Interview and Field Investigation -

3-0. Outline

3-1. Natural Environment and Human Activities

3-1-1. Rivers

- (1) Basic index and river observation systems
- (2) Flood

3-1-2. Fishery

- (1) Outline
- (2) Fishing seasons
- (3) Fishing rights

3-1-3. Nature conservation and forest disruption

- (1) Forest disruption
- (2) Fish and river dolphin

3-2. Human Life, Public Health and Medical Care

3-2-1. Wells

3-2-2. Urine and feces

3-2-3. Outline of medical care

3-2-4. Water supply

- (1) Outline
- (2) Facility
 - a. Water intake and aqueduct
 - b. Waterworks and distribution

3-2-5. Drainage of rainwater and wastewater

3-2-6. River pollution

- (1) Water pollution of fishing areas
- (2) Water Pollution due to industry and human activities

3-2-7. Solid waste

- (1) Occurrence and collection
- (2) Disposal
- (3) Scavenger at Strung Mean Chey

3-2-8. Chemical pollutants in environment

3-2-9. Air pollution

3-3. Visit on Governmental Offices

3-3-1. Ministry of Environment

- (1) Organization
- (2) Problems to be solved
 - a. General conditions
 - b. Enactment of "Environmental Law"
 - c. Overcome of inefficiency
 - d. Things to be needed

3-3-2. Ministry of Rural Development, Department of Rural Health Care

- (1) Organization
- (2) Ensuring safe drinking water
- (3) Spread of lavatories

3-3-3. Visit on medical facilities

- (1) Community Health Center
- (2) Kandal Stung District Hospital
- (3) National Mother -and-baby Health Center

3-3-4. Ministry of Agriculture, Forestry and Fisheries

(1) Department of Agricultural Hydraulic and Hydro-Meteorology

- a. Organization
- b. Problems regarding water utilization
- c. laboratory

(2) Department of Fisheries

- a. Objects of the Department
- b. Fishing rights
- c. Problems to be overcome

3-3-5. Water Supply Authority of Phnom Penh Municipality

- a. Outline
- b. Present situation of ODA

3-3-6. Public Work Office of Phnom Penh Municipality

(1) Cleansing activities

- a. number of employee
- b. Collection
- c. Charge
- d. Disposal

(2) Sewerage

3-4. Visit on International Cooperative Organizations

3-4-1. Japan International Volunteer Center

- (1) Organization
- (2) Activities

4. Basic Study of Environmental Pollution (1)

- Mercury Levels in Fish in Cambodia -

4-1. Introduction

Mercury pollution due to gold mining in the regions such as the Amazon river basin, Philippines, and Indonesia has become serious problem for human health in recent years.

¹⁾ There are currently active small scale placer gold mining in Cambodia. ²⁾

Mercury (inorganic mercury) is used in the mining process as an amalgamate to separate the fine gold particulate from other mineral components. It's known that inorganic mercury is methylated in the aquatic environment, the resulting methylmercury (MeHg) is accumulated in various organisms through a biomagnification process. The major source of MeHg intake for humans from the environment is fish and shellfish. ³⁾ Minamata disease is MeHg poisoning that occurred in human who ingested fish and shellfish contaminated by MeHg discharged in waste water from a chemical plant in Japan. ⁴⁾ Fish is the most important protein source in Cambodia. ⁵⁾

Therefore, if fish were remarkably contaminated by mercury in Cambodia, the residents might be exposed to the hazard of MeHg poisoning. Here we report the current situation of mercury pollution in fish in Cambodia.

4-2. Materials and Methods

Fish samples consisted of 15 species were collected at the markets and fishing villages in Phnom Penh and its vicinity in November and December 1995, and in February 1996. Sixty-three samples were originally caught at the Mekong river (n=8), the Tonle Sap river (n=28), the Tonle Sap lake (n=24), and the Bassac river (n=3), and nearly half of them were raised at the cages in the rivers. Six samples were from unidentified origin.

Skin-off fillets of fish were homogenized by a blender, the homogenates were mineralized with nitric, perchloric, and sulfuric acid in test tubes in aluminum blocks on hot plate. The total mercury (T-Hg) concentrations were analyzed by semi-automated cold vapor atomic absorption spectrometry (Mercury Analyzer 4000, Sanso Seisakusyo Co., Japan). ⁵⁾ MeHg was not determined in this study.

4-3. Results and Discussion

T-Hg concentrations in fish were in the range 0.020 - 0.28 $\mu\text{g/g}$ (wet basis) and showed log-normal distribution (Fig. 4.1). The mean and median values were 0.10 and 0.095 $\mu\text{g/g}$ respectively (Table 4.1). These values were lower than those in fish caught in the polluted areas such as the Amazon river and the Agano river basin ^{1,6-9)}, and were the same level with those in fish from non-polluted area of Thailand at 1975-6 (Table 3). ¹¹⁾

Maximum concentration was lower than the provisional regulatory standard in fish in Japan ($0.4 \mu\text{g/g}$ of T-Hg), or maximum permissible concentration for human consumption ($0.5 \mu\text{g/g}$, WHO).¹⁰⁾ These results suggest that mercury pollution is not serious in Phnom Penh at present.

According to previous reports,^{3, 6)} more than 75% of T-Hg in muscle tissue of fish is usually MeHg. If one eat daily 400g of fish, containing $0.30 \mu\text{g/g}$ of T-Hg, the total body burden of MeHg will reach the threshold level of MeHg poisoning in the most sensitive one.³⁾ Therefore, it will be necessary to examine the daily fish intake of the people who eat a lot of fish, e.g. fishermen and their families, and the mercury levels in their hair and blood. We carried out the pilot study on mercury exposure level for residents in Phnom Penh and its vicinity in the same periods collected fish, the resulting T-Hg level in scalp hair of peoples in the fishing and farming village were 2.89 to $9.21 \mu\text{g/g}$ ($n=19$) and 1.82 to $6.91 \mu\text{g/g}$ ($n=11$) respectively. These values were non-effect level for human health. However, because Phnom Penh is inactive gold mining and is far from active area, it will research for the situation of mercury use and environmental contamination in gold mining area such as Siem Reap, Preah Vihear, and Ratanakiri.

It has been reported that there was positive correlation between T-Hg concentration and the body weight of fish and that T-Hg in carnivorous species were higher than that in omnivorous or herbivorous species.^{1, 3, 7, 8)} In this study, T-Hg concentrations were quite variable depending on fish species, size, and food habits (Table 4.1), but there were no significant correlation between mercury level and the body weight (Fig. 4.2), or their food habits. This might partly due to raising in the cages in the half of the samples; their body weight should be different at the start of raising, and they had been kept in different conditions for various periods with different quality and frequency of feeding. therefore, it will be necessary to research separately on mercury level in wild and cultivated fish.

References:

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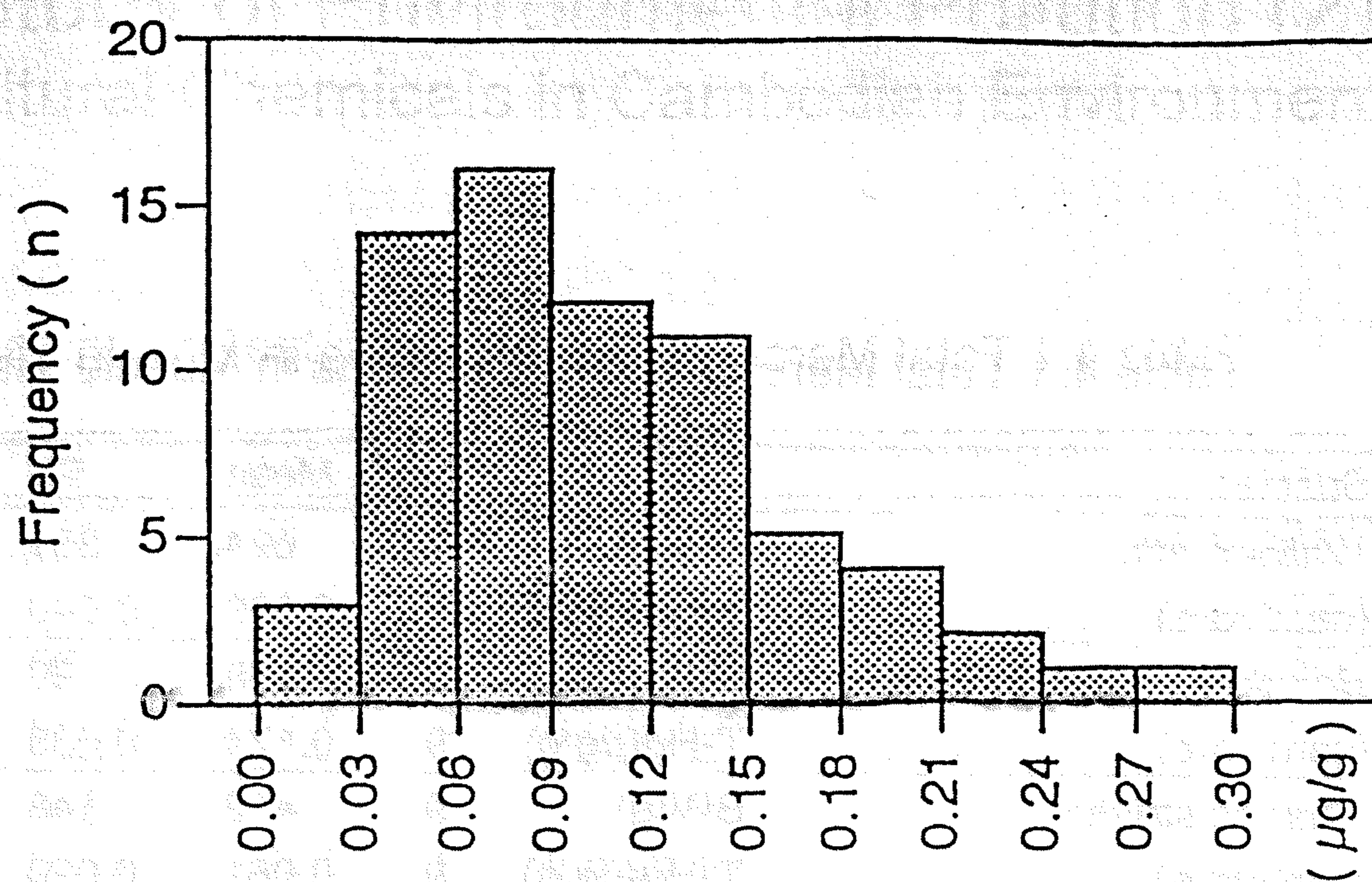


Fig. 4.1 Histogram of Total Mercury Concentration in Fish

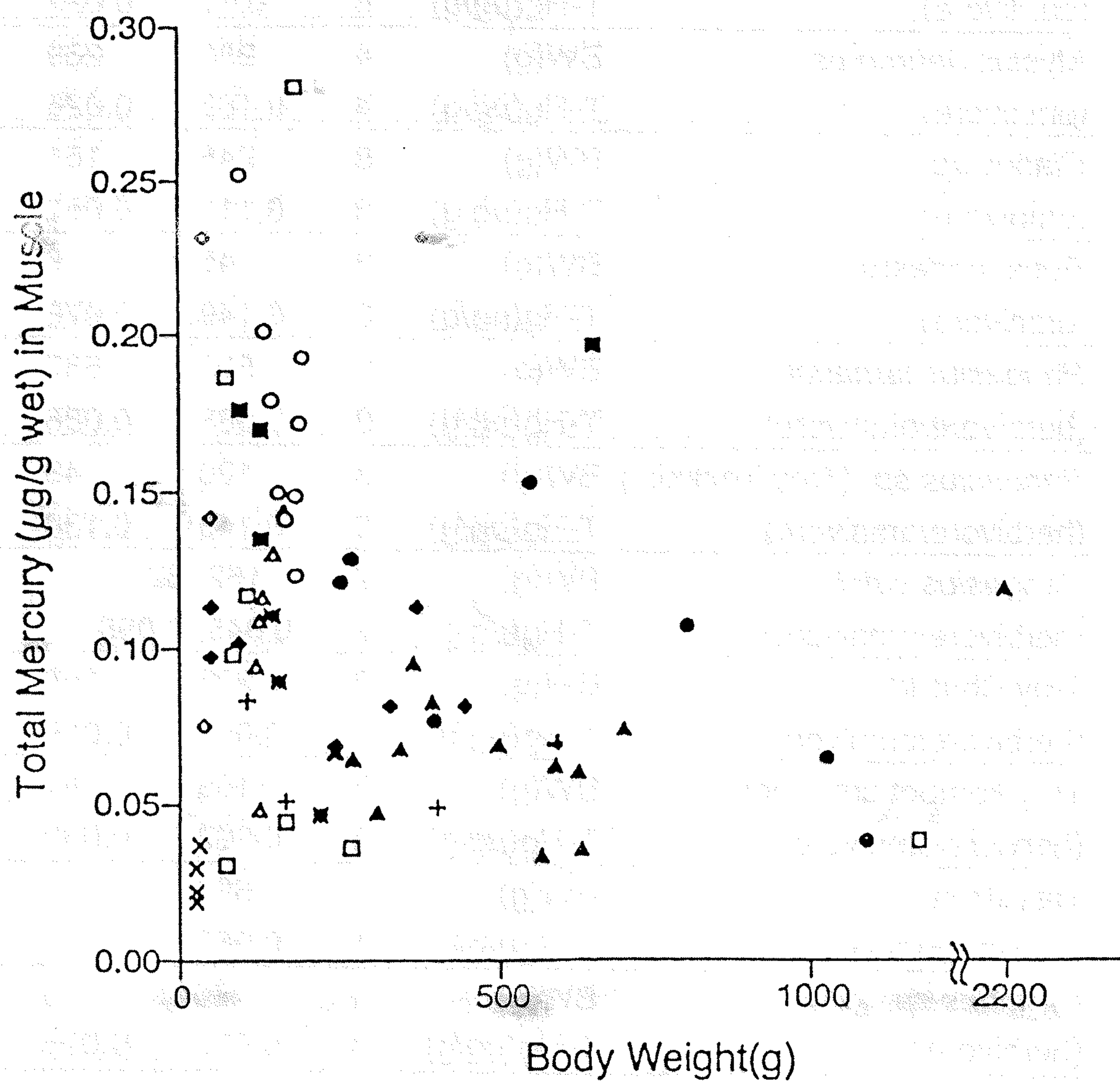


Fig. 4.2 Relationship between body weight and Total Mercury concentration in muscle

- *Belodontichthys dinema* ● *Wallago attu* ◆ *Clarius sp.*
- *Mystus neumurus* □ *Pangasius sp.* ◊ *Botia modesta*
- ▲ *Channa sp.* △ *Oxyeleotris marmorata* × *Cirrhinus sp.*
- + Trey Chork ✱ Trey kombot chromos ◌ Trey Krum

Table 4.1 Total Mercury Concentrations in Muscle Tissues in Fish

Species		N	Mean	SD	Min	Max
<i>Wallago attu</i>	BW(g)	7	624	351	262	1090
(carnivore)	T-Hg(μ g/g)	7	0.099	0.040	0.039	0.153
<i>Belodontichthys dinema</i>	BW(g)	9	158	30	96	187
(carnivore)	T-Hg(μ g/g)	9	0.174	0.039	0.124	0.252
<i>Channa striatus</i>	BW(g)	9	412	148	244	633
(carnivore)	T-Hg(μ g/g)	9	0.061	0.020	0.033	0.095
<i>Channa micropeltes</i>	BW(g)	4	1008	799	503	2200
(carnivore)	T-Hg(μ g/g)	4	0.083	0.031	0.060	0.129
<i>Oxyeleotris marmoratus</i>	BW(g)	6	135	18	118	164
(carnivore)	T-Hg(μ g/g)	6	0.11	0.033	0.048	0.14
<i>Mystus neumurus</i>	BW(g)	4	250	269	94	652
(omnivore)	T-Hg(μ g/g)	4	0.169	0.026	0.135	0.197
<i>Clarius sp.</i>	BW(g)	8	245	161	49	447
(omnivore)	T-Hg(μ g/g)	8	0.111	0.051	0.068	0.231
<i>Botia modesta</i>	BW(g)	3	45	6	41	51
(omnivore)	T-Hg(μ g/g)	3	0.149	0.078	0.075	0.231
<i>Pangasius larnaudi</i>	BW(g)	3	503	587	73	1172
(herbivore/omnivore)	T-Hg(μ g/g)	3	0.088	0.086	0.037	0.187
<i>Pangasius sp. (Trey Tokkair*)</i>	BW(g)	3	120	48	74	180
(herbivore/omnivore)	T-Hg(μ g/g)	3	0.143	0.130	0.031	0.281
<i>Pangasius sutchi</i>	BW(g)	2	162, 82			
(herbivore/omnivore)	T-Hg(μ g/g)	2	0.045, 0.098			
Trey Chork*	BW(g)	3	223	158	104	402
(herbivore/omnivore)	T-Hg(μ g/g)	3	0.061	0.019	0.049	0.083
Trey kombot chromos*	BW(g)	3	169	41	139	216
(herbivore/omnivore)	T-Hg(μ g/g)	3	0.082	0.032	0.047	0.110
Trey Krum*	BW(g)	1	593			
(herbivore/omnivore)	T-Hg(μ g/g)	1	0.069			
<i>Cirrhinus sp.</i>	BW(g)	4	26	3	23	30
(herbivore)	T-Hg(μ g/g)	4	0.027	0.008	0.020	0.037
Total	BW(g)	69	311	346	23	2200
	T-Hg(μ g/g)	69	0.105	0.060	0.020	0.281

*: Local name

5. Basic Study of Environmental Pollution (2)

- Agricultural Chemicals in Cambodian Environment -

5-1. Preface - Meaning of Pesticides' Research -

5-2. Types and Characteristics of Pesticides Used in Cambodia

5-3. Interview of the Pesticide Use

5-4. Analysis of Organochloride Compounds

5-4-1. Purposes of the research

5-4-2. Material and Method

5-4-3. Results

5-5. Possibility of Pesticide Pollution in the Future

5-6. Items to be Studied

5-7. Summary

Table 5.1 Concentrations of organochlorines in the fishes from Phnom Penh, Cambodia

Local name	Scientific name	N	Body length(cmTL)	Body weight(g)	Fat content(%)	Concentration				
						HCB	HCHs	CHLs.	DDTs	PCBs
Carps										
Trey kombot chrormos	---	3	20.0-22.0	139-216	0.66-2.3	N.D.	0.11-0.28	N.D.-0.42	1.9-8.6	N.D.
			20.8	169	1.5		0.16	0.15	3.9	
Trey chrork	<i>B. laevis</i>	1	24.0	402	5.8	N.D.	N.D.	0.041	20	N.D.
Catfishes										
Trey prar	<i>P. sutchi</i>	3	19.5-23.5	82-180	0.55-1.2	N.D.	N.D.-0.15	N.D.-0.031	2.6-9.3	N.D.
			21.2	141	0.90		0.076	0.010	5.8	
Trey klung hay	<i>B. dinema</i>	3	28.5-32.5	163-187	0.74-7.3	N.D.	N.D.-0.28	N.D.	4.3-39	N.D.-4.5
			30.3	178	3.0		0.93		22	2.4
Snakeheads										
Reserver	<i>C. sp.</i>	3	25.5-28.0	267-363	0.32-0.99	N.D.	N.D.	N.D.	1.1-1.8	N.D.
			26.8	311	0.65				1.5	
Fish paste										
Prarhoc	---	2	---	---	5.7-8.8	N.D.-0.079	N.D.-0.51	N.D.-0.40	35-234	N.D.
					7.3	0.040	0.26	0.20	140	

Range

Mean

---: No information available.

N.D.: Not detectable quantity.

Table 5.2 Concentrations of Σ DDT in the fishes from Phnom Penh and other water systems

Sample name	Σ DDT	Sampling year	Reference
Phnom Penh, Cambodia			
Carp	210-340	1995	This study
Catfish	210-4700		
Snakehead	110-460		
Fish paste	420-4100		
Java			
Carp	1400-50000	1986-1987	Sri Noegrohati <i>et al.</i> , 1992
Tapajos river, Brazil			
Freshwater fishes	730-10000	1994	Esaki <i>et al.</i> , unpublished
India			
Fishes and prawn	79-5600	1989	Kannan <i>et al.</i> , 1992
Lake Michigan, America			
Lake trout	4000*	1975	Swackhamer and Hites, 1988
Lake trout	2000*	1977-1979	
Lake Siskiwit, isla Royale, lake Superior, America			
Lake trout	68000*	1975	Swackhamer and Hites, 1988
Baltic sea			
Cod liver	9400-25000	1971-1980	Kannan <i>et al.</i> , 1992

*Concentration of *p,p'*-DDE.

6. Summary of the Research and Perspectives of Further Investigation

In research carried out in November 1995 and February 1996, findings about present environmental situation and issues to be solved in Phnom Penh and its suburban farming villages are as follows.

6-1. Present Situation of Environmental Quality in Cambodia

6-1-1. Mercury Pollution

1. There is no mercury pollution sources such as caustic soda factories using mercury electrode, aldehyde factories and mercury mines in Cambodia.
2. The mercury concentration in muscle tissues of 69 fish (15 species) ranged from 0.020 to 0.28 ug/g (median 0.095 ug/g). These amounts were found to be almost the same with the background level of mercury.
3. The head-hair mercury concentration of 31 employees of a printing factory ranged from 2.2 to 10.6 ug/g. These amounts are within the normal ranges of head-hair mercury concentration.
4. Based on the above findings, mercury pollution caused by human activities is insignificant at the present situation.

6-1-2. Pesticide Pollution

1. The maximum concentration of HCB, HCHs, CHLs, DDTs and PCBs in fish muscle tissue, which is one of the main sources of animal protein for Cambodian residents, were 0.079, 0.51, 0.42, 234 and 4.5 ng/g wet weight, respectively. Daily intakes of these chemicals by Cambodian residents, calculated from the above figures, do not exceed the acceptable intake of FAO/WHO and the criteria of the Japanese Ministry of Welfare.
2. In spite of the above findings, because pesticides amounts used in Cambodia will increase with economic growth of this country, there is a possibility that pesticide pollution will prevail in this country. Therefore, continuous monitoring and research are needed for the protection of the pesticide pollution.

6-1-3. Medicine

In this research, exposure of heavy metals and pesticides to babies was tried to be studied. It is known that the exposure of these substances to an embryo and a baby is caused through the placenta and amniotic fluid, and mother's milk, respectively. Therefore, sampling of the blood in the placenta and a navel string as well as those of mother's blood

and milk in puerperium was intended.

But the communication between our research group and the persons concerned in Cambodia was not enough. For example, discussion on human rights, informed consent and so forth was not carried out satisfactorily. As a result, the sampling of blood was obliged to be postponed.

Instead, National Mother and Child Care Center, Candal Stung District Hospital and Community Health Center were visited in order to know the present situations of perinatal care. 10 to 20 ml of mother's milk could be gained from mothers in puerperium both in Community Health Center and the Kahndal Hospital. The samples gained were transported to Japan and now under analysis of pesticides.

Though our stay in Cambodia was so short, issues found there are as follows.

1. Candal Stung District Hospital and Community Health Center were not prepared well as obstetrics and gynecology. It was thought that these facilities were unable to play a part well as the first referral when something wrong occurs during childbirth at a mother's home, which occurs so often in Cambodia. This is caused by the lack of medicine and medical equipment as well as the lack of medical knowledge.
2. As seen above, it was thought that, in the suburban areas of Phnom Penh, the perinatal referral system is not well prepared. This is caused by the lack of communication tools, traffic inconvenience and small number of medical staffs at a time of emergency, in addition to issues mentioned above.
3. It is difficult to reduce infant mortality without careful perinatal management. It is necessary to change a mothers' habit to go to a clinic only when they want and to go to a hospital only at a time of childbirth if physical abnormality does not occur around them.

6-1-4. Drinking water

The following findings were gained in the study.

1. Raw water of municipal water supply in Phnom Penh City is polluted by wastewater discharged from the city.
2. In a purification process of the waterworks, solid matter was not removed well. It was thought that coagulant was added without careful understanding the relationship between solid matter in the raw water and an amount of the coagulant to maximize the removal efficiency.
3. The amount of chlorine added for disinfection in the waterworks was thought to be inadequate to attain the object. This perhaps results from the fact that water quality, especially solid matter, after a rapid sand filtration is not stable and that this makes difficult to dose the chemical for each water quality.
4. The water distribution system of the city was found too old to work well. As water

pressure is so low that there is a possibility that dirty water around distribution pipes come into the pipes.

5. The number of faucets is not enough to keep the city hygienic.
6. Service pipes in a superannuated building were found also to be superannuated. This resulted in deterioration of water quality.
7. There were still many city residents who could not enjoy the convenience of the municipal water supply.
8. In the research in 1996 and 1996, water quality of water sellers, wells in farm lands and rivers used by residents along the rivers were not investigated. This remains to be made clear.

6-1-5. Drainage

1. The sewerage system of the capital constructed before 1950's was found to be so superannuated. As a result, wastewater could not be drained away from streets. This makes the city insanitary.
2. The flowing capacity of unlined urban drains was also thought to be so small. In addition, its water quality was not good. It was thought that in the rainy season, dirty water will overflow and make roads under water.
3. Industrial activities were being reconstructed. Though the amount of industrial wastewater discharged was thought to be so small, it was discharged without any governmental restriction. The environmental effects of it were unknown and remains to be made clear.
4. The Basac and Mecong river, which were a destination of urban wastewater, were found to be so polluted. As the river water was used as raw water of Phnom Penh municipal water supply, it was thought to be polluted, too.
5. There is a possibility that water and soil of large wet lands in the western suburb of Phnom Penh, which were another destination of urban wastewater, were also polluted.

6-1-6. Solid wastes

1. Solid wastes were thrown away on the street in Phnom Penh. Collection of the wastes by the municipality office seemed not to be made so frequently. As a result, a large amount of solid wastes always remained on the street. The disposal and collection was thought not to carried out under a comprehensive plan.
2. As there is little habit to use lavatory, perhaps urine and feces were mixed with municipal solid wastes. This causes the wastes so infectious.
3. Both Industrial and urban activities were being restored. And an amount of industrial and medical wastes were thought to increase. Evidence that hazardous industrial or

medical wastes were disposed separately from domestic wastes and safely was not found.

4. A landfill site at Strung Mean Chey was visited. Burning in the field was still adopted as a measure to make wastes stable.
5. Collection of solid wastes were carried out at a charge. But income was found not to increase substantially.

6-2. Recommendation (Things to be done)

As a result of the research , recommendations are as follows.

6-2-1. Hygiene

In order to ensure people's healthy lives and to let them show their ability to the full, it is essential to spread hygienic and medical knowledge to them and to improve their total environment. It is important to let them keep their surroundings hygienic. In this respect, it is urgently needed to popularize a habit to use a toilet. It is also important to create an atmosphere in the Cambodian society to look upon motherhood so that a woman, who is one of the weakest groups in a modern society, can experience pregnancy and childbirth safely and bring up containedly her children who will create next generation.

6-2-2. Improvement of drinking water quality

Data on water quality of water supply in Phnom Penh City and those of well, rain and pond showed that a substantial amount of bacteria and *Escherichia coli* remained in them. It is well known that the number of children who die in their five years of life is about 150 per 1,000 live birth in Asian developing countries. This high mortality seems to result mainly from infectious disease such as diarrhea, enteritis, pneumonia and bronchitis and be deeply related with unhealthy conditions of the residents' environment. In addition, it is also well known that the improvement of drinking water quality is so effective to reduce these infectious diseases. This is also the case with Cambodia. In other words, the improvement of drinking water quality is most urgent in Cambodia.

The water supply in Phnom Penh is not good for people's health and drinking. This results mainly from the eraw water's pollution, the poor operation of the waterworks and the superannuated distribution pipes and buildings, as mentioned before.

Therefore, it is necessary to restore the old water supply system and to add a new water supply network to it. Possibly, water quality of the Mecong river is better than that of the Sap. If so, it is desirable to change an abstraction point of raw water from the Sap to the Mecong. The operation of the existing waterworks should be improved, especially in the dosage of coagulants and chlorine. Points of water leakage have to be found and repaired. If this is impossible, superannuated pipes have to be exchanged with new ones.

The author strongly argue that public faucets to which residents can access freely

should be constructed as many as possible with all possible efforts to their environment clean and healthy.

6-2-3. Rehabilitation and new construction of a urban drainage system

The wastewater produced in Phnom Penh City was discharged to the Sap or the Bassac river, or the wetlands in the west of the city via a sewerage system, which had been constructed before 1950's, and open channels in the city without any treatment. On the other hand, the Sap is the source of municipal water supply and flows backward in a rainy season. Therefore, it seems that urban used water pollutes the water supply.

In addition, many houses were constructed over the open channels and the wet lands, where vegetables were often cultivated and fishing was also carried out. These residential conditions seem to badly influence people's health.

Wastewater should be treated and be discharged. Therefore, as in the case of water supply, it is necessary to restore the old sewerage system, to add a new sewage pipes' network to the old system and, most of all, to construct a sewage treatment plant. Facilities such as pump stations and gates have to be restored and/or constructed to discharge purified wastewater to the rivers and wetlands west of the city. Important is that these activities are carried out harmoniously under one comprehensive plan.

6-2-4. Solid Wastes

With the restoration of Cambodian economy, the amount of solid wastes are sure to increase year by year. Quality and quantity of each waste should be estimated correctly. In case of industrial wastes, this estimation should be carried out in each type of industry. Attention is also needed to medical wastes.

As seen in 6-1-6, collection and disposal are not well prepared both institutionally and technically. To make a master plan which comes conditions of this country into view and governs the above activities is needed. Transition from burning in the field to sanitary landfill is needed. Health of scavengers should be taken account of.

Urbanization and/or modernization are in progress also in rural cities and farm villages. Production, collection and disposal of wastes in these area are to be taken into consideration.

6-2-5. Creation of a structure for comprehensive management of Cambodian environment.

In order to keep and improve the environmental quality of Cambodia effectively, a structure which can take a broad view of present situations and work out a powerful policy on environmental management should be created. This structure has to cover not only human environment but also natural environment.

Practically, this type of structure will be established after "Environment Law" passes

the Diet. Things to be established are as follows;

1. Legal regulation framework on air, water, noise, vibration, solid waste and so forth.
2. Setting up criteria and/or action levels of the above items and making use of them in good working order.
3. Education of staffs
4. Construction of a research laboratory. Measurement of environmental quality and analysis of data gained.

6-2-6. Spread of environmental education

It is very important for Cambodian children and adults to know the present situation of Cambodian environment and the importance to preserve and improve it. Every kind of efforts should be taken to attain this object.

6-3. Prospect of the Research

Things to be done at next step in our research are summarized as follows.

6-3-1. Mercury analysis

It is necessary;

1. To elucidate the level of mercury concentration in fish, farmers and fishermen in each living area of them and each season.
2. At the same time, to know the details of their fish consumption (amounts, species and so on).
3. To gather information on environmental effects of placer mining in areas such as Siem Reap, Preah Vihear and Ratanakiri.
4. To collect information on mercury-related industries in neighboring countries and to make clear the possibility of border transgression of mercury pollution.

6-3-2. Pesticide analysis

1. Sampling in other areas

Fish analyzed in 1995 and 1996 were caught or purchased in Phnom Penh and its neighboring suburbs. It is a matter of course that the results gained cannot represent the average of Cambodia. Therefore, sampling in other broadened areas is needed.

Perhaps there are some specific small areas which are highly polluted with DDT and other organochlorine pesticides. To prevent Cambodian residents from high exposure to the chemicals, it is necessary to try to find such areas and to evaluate the level of contamination.

2. Analyzing other pesticides

In this study, DDT and its related organochlorine pesticides were analyzed. In the further study, analysis of organophosphorus pesticides and carbamate insecticide is also needed.

3. Analyzing living creatures in a higher rank

Organochlorine pesticides have a tendency to accumulate in living creatures in a higher rank. Therefore, in order to elucidate effects of the pesticides on human body, it is useful to investigate them which live on fish.

To analyze pesticides and other chemicals in river dolphins and waterfowls will give useful information on pesticide pollution in this country.

6-3-3. Medical care

In making proposals to improve medical care in Cambodia, it is necessary to keep in mind the transfer of appropriate technology and know-how. Things to be done are;

1. To study following items about home delivery and to make issues clear.
 - a. Basic obstetrics function (midwife, helpers' technique and "treatment and resuscitation" for a newborn baby.
 - b. women's ideas and behaviors on pregnancy and delivery
 - c. Measures to transport a mother and her child in an emergency, and its destination.
2. To understand disease structures and living environments at a village-level.
 - a. Study on a newborn baby and an infant.
 - b. Women's ideas and behavior before menopause.
 - c. Study on adult people
 - d. Status quo of water quality and relation of it with various diseases
 - e. Situation of pesticide use and relation of it with various diseases
3. To find ways to ensure and utilize social sources to let people know the importance of their health.

6-3-4. Engineering research on urban sanitation

Study in 1995 was carried out not quantitatively but qualitatively. Therefore, in the next step, qualitative evaluation of present situations of Cambodian environment is needed. Things to be studied are as follows.

1. As for urban water supply, water quality of raw water, each process of waterworks and faucets will be analyzed periodically and issues will be made clear. In a rural district, quality of well water, its roles and maintenance ways will be studied both in a rainy season and in a dry season.
2. With regard to urban drainage, quality of urban used water, river water and "wetland

water and mud soil will be analyzed quantitatively. In addition, existing sewage treatment plants such as that in Bat Dam Bang constructed by French NGO will be investigated.

3. Regarding solid wastes produced in urban areas, quality and quantity analysis of household wastes will be made first. Quality and quantity of hazardous wastes produced in various industries and hospitals are also investigated next. In addition, future sources of them will be evaluated. Large enterprises which produce a large amount of harmful and/or harmless wastes now and in the future will be identified. Quality and quantity of solid wastes and their disposal method in a rural area will also be studied.
4. Based on the above quantitative results, a proposal of total institutional and technological frameworks of water supply management and used-water management will be made separately. In addition, A proposal will be made on the structure of solid waste management. Whether solid wastes are classified into general and industrial waste as in Japan or into hazardous and non-hazardous waste remains to be determined.

Postscript

- Cambodian Environment: Now and the Future -

With the restoration of economic activities, environmental issues such as urbanization, exposure to pesticides and/or heavy metals, and deforestation are becoming so serious in countries along the Mekong River.

Like other countries, Cambodia is in the midst of the reconstruction and reorganization as a nation. As a result, residents' environment is getting worse. To attain the national goal as fast as possible and to keep environmental degradation as little as possible, appropriate technologies and institution should be adopted. In addition, careful monitoring and assessment of the environment should be carried out simultaneously.

The basic purpose of our study is to support the Cambodian to restore and create their nation, especially in the field of medical care, environmental monitoring and sanitary engineering. Our group intends to play some role for the country to create comprehensive frameworks for environmental management that are compatible with sustainable development of the country. We want to reach this goal, cooperating with Cambodian specialists, through procedures summarized in the previous chapters.

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